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72: Creator: Toshifumi ITO, c/o Nippon Denshi Kiki Kabushiki kaisha, 1671-1, Kasukawa-cho, Isesaki-shi

72: Creator: Tadao SUWA, c/o Nippon Denshi Kiki Kabushiki kaisha, 1671-1, Kasukawa-cho, Isesaki-shi

71: Applicant: Nippon Denshi Kiki Kabushiki Kaisha, 1671-1, kasukawa-cho, Isesaki-shi

74: Agent, Fujio SASAJIMA, Patent Attorney

SPECIFICATION

1. Title of the Utility Model

Air-fuel ratio sensor

2. Claims for the Utility Model

Air-fuel sensor comprising an inside electrode, an oxygen ion conductive solid electrolysis layer, and an outer electrode which are sequentially accumulated on one side of the substrate, and further comprising a diffusion layer which covers the solid electrolysis layer and also the outside electrode, for detecting an air-fuel ratio from a current value obtained by applying a voltage between the inside electrode and the outside electrode, the voltage application direction in a rich region being reversed from the voltage application direction in a lean region, wherein the inside electrode is formed into a size larger than the solid electrolysis layer and the diffusion layer so that the outer peripheral portion thereof is exposed to a gas atmosphere to be measured.

3. Detailed Description of the Utility Model

(Field of Industrial Application)

The present utility model relates to an air-fuel ratio sensor. In particular, the present utility model relates to an air-fuel ratio sensor which is attached to an exhaust pipe in an internal combustion engine and is used for measuring an oxygen concentration and the like in the exhaust gas which has a close

relationship with an air-fuel ratio (λ) of an air-fuel mixture supplied to the engine so as to utilize the measurement result of the oxygen concentration for supplying a feedback signal in an air-fuel ration feedback control.

(Prior Art)

Conventionally, as this type of air-fuel sensor, there has been a sensor such as shown in Figs. 3(a), (b) and 4, for example. This sensor is also referred to as a membrane-structure wide-band sensor. The sensor uses an oxygen ion conductive solid electrolyte, and can detect air-fuel ratios in a wide range by changing the direction of applying a voltage depending on a case of detecting an air-fuel ratio in a lean region and a case of detecting an air-fuel ratio in a rich region. This type of sensor has been known in Japanese Laid-Open Patent Publication No. 59-67455 and the like.

The air-fuel ratio sensor (sensor element portion) shown in Figs. 3(a), (b), and 4 will be described. On one side of a substrate 1 made of Al_2O_3 and the like, an inside electrode 2 containing platinum as a main component, an oxygen ion conductive solid electrolyte layer 3 made of ZrO_2 and the like, and an outside electrode 4 containing platinum as a main component are sequentially accumulated by printing for example. Then, the solid electrolyte layer 3 and also the outer electrode 4 are coated with a diffusion layer 5 made of Al_2O_3 and the like for controlling the speed of gas diffusion by printing. A heater 6 is also

embedded in the substrate 1. The reference numerals 2a, 4a denote lead wire connecting portions for the electrodes 2, 4, respectively.

In the case of detecting an air-fuel ratio in the lean region, as shown in Fig. 3(a), the inside electrode 2 is used as a positive electrode and the outside electrode 4 is used as a negative electrode. In this state, a voltage V is applied in such a manner that a current I is allowed to flow from the inside electrode 2 toward the outside electrode 4. At this time, oxygen (oxygen ion O^{2-}) in an amount proportional to the current I is pumped from the diffusion layer 5 and passes through the solid electrolyte layer 3 from the outside electrode 4 to the inside electrode 2. However, the amount of oxygen entering into the diffusion layer 5 due to gas diffusion is proportional to the oxygen concentration in the exhaust gas and is restricted by this oxygen concentration. Therefore, when the voltage V is at a specific value or larger, the amount of oxygen pumped from the diffusion layer 5 is larger than the amount of oxygen entering into the diffusion layer 5, and the current I reaches a limit value. Since this limit current is proportional to the oxygen concentration in the exhaust gas, the oxygen concentration, and therefore, the air-fuel ratio in the exhaust gas can be detected by measuring the limit current (see the right side in Fig. 5).

In the case of detecting an air-fuel ratio in the rich region, as shown in Fig. 3(b), the inside electrode 2 is used as a negative electrode and the outside electrode 4 is used as a positive

electrode. In this state, a voltage V is applied in such a manner that the current I is allowed to flow in a direction reversed from the above. At this time, oxygen passes through the solid electrolyte layer 3 from the inside electrode 2 to the outside electrode 4, and entered into the diffusion layer 5. The oxygen reacts with carbon monoxide, entered into the diffusion layer 5, in the diffusion layer 5 in the following formula:

$$CO+1/2O_2 \rightarrow CO_2$$

In this manner, a state in which oxygen partial pressure in the diffusion layer 5 is extremely small is created in the rich region as well, thereby keeping the diffusion layer 5 in a stoichiometric state (exhaust state of $\lambda=1$).

In this case, the air-fuel ratio is detected from the amount of carbon monoxide. Specifically, the amount of carbon monoxide entering into the diffusion layer 5 due to gas diffusion is inversely proportional to the air-fuel ratio. Then, oxygen is supplied into the diffusion layer 5 in accordance with the amount of the carbon monoxide so as to increase the oxygen partial pressure therein, in an attempt to always establish the partial pressure difference. For this reason, as the carbon monoxide concentration increases, the limit current also increases. The carbon monoxide concentration, and therefore, the air-fuel ratio in the exhaust gas can be detected by measuring the limit current (see the left side in Fig. 5).

In other words, the air-fuel ratio is detected from the current I generated in the individual cases where the voltage of

$V=V_0$ is applied in the lean region and where the voltage of $V=-V_0$ is applied in the rich region (see Fig. 6).

(Problems which the Utility Model Solves)

In the conventional air-fuel sensor such as described above, however, the inside electrode 2 is covered with the solid electrolysis 3. Therefore, in the detection in the lean region, when oxygen is allowed to flow from the solid electrolysis layer 3 toward the inside electrode 2, the oxygen partial pressure within the inside electrode 2 increases. The increased oxygen partial pressure destroys the solid electrolysis layer 3 or causes occurrence of backflow of oxygen toward the outside electrode 4 through the pores of the solid electrolysis layer 3 (X in Fig. 3(a)), resulting in a problem that the decomposition ability is degraded and the detection error becomes large. In addition, in the detection in the rich region, when the oxygen is allowed to flow from the solid electrolysis layer 3 toward the outside electrode 4, it takes much time for the inside electrode 2 to capture oxygen, resulting in a problem that the responsiveness as a sensor is degraded.

In view of the problems residing in the prior art such as described above, an objective of the present utility model is to enhance the durability, detection accuracy, responsiveness and the like of this type of air-fuel sensor.

(Means by which the Problem is Solved)

In order to achieve the above-described objective, in the present utility model, an air-fuel sensor comprises an inside electrode, an oxygen ion conductive solid electrolysis layer, and an outer electrode which are sequentially accumulated on one side of the substrate, and further comprising a diffusion layer which covers the solid electrolysis layer and also the outside electrode, for detecting an air-fuel ratio from a current value obtained by applying a voltage between the inside electrode and the outside electrode, the voltage application direction in a rich region being reversed from the voltage application direction in a lean region, wherein the inside electrode is formed into a size larger than the solid electrolysis layer and the diffusion layer so that the outer peripheral portion thereof is exposed to a gas atmosphere to be measured.

(Function)

Specifically, the inside electrode is formed into a large size and is exposed to the gas atmosphere to be measured, that is, the exhaust gas. Due to this arrangement, oxygen is smoothly discharged or introduced, thereby enhancing the durability, detection accuracy, and responsiveness.

(Embodiments)

Hereinafter, an embodiment of the present utility model will be described with reference to Figs. 1(a), (b), and 2. The

constituent elements identical to those of prior art example are denoted by the same reference numerals.

The portions different from those of prior art example will be described. An inside electrode 2 is formed into a size larger than a solid electrolysis layer 3 and a diffusion layer 5, and an outer peripheral portion of the inside electrode 2 is exposed to the gas atmosphere to be measured, that is, exhaust gas.

In this arrangement, in the detection in the lean region such as shown in Fig. 1(a), when oxygen is allowed to flow from the solid electrolysis layer 3 toward the inside electrode 2, the oxygen is smoothly discharged from the outer peripheral portion of the inside electrode 2. As a result, the increase in the oxygen partial pressure within the inside electrode 2 can be suppressed, and therefore, the destruction of the solid electrolysis layer 3 is prevented and the durability is enhanced. Further, since the backflow of oxygen such as described above (X in Fig. 3(a)) does not occur, the detection of decomposition ability of the sensor is improved and the detection accuracy is enhanced.

In addition, in the case of detection in the rich region such as shown in Fig. 1(b), when oxygen is allowed to flow from the solid electrolysis layer 3 toward the outside electrode 4, the oxygen is smoothly introduced into the inside electrode 2 due to the arrangement that the outer peripheral portion of the inside electrode 2 is exposed to the exhaust gas. As a result, the responsiveness is enhanced.

(Effect)

As described above, according to the present utility model, increased durability, detection accuracy, and responsiveness of the air-fuel sensor can be obtained.

4. Brief Description of the Drawings

Figs. 1(a), (b) are cross-sectional views of an air-fuel sensor according to an embodiment of the present utility model in the cases of detection in the lean region and the detection in the rich region, respectively; Fig. 2 is a plain view of the air-fuel sensor of Fig. 1; Figs. 3(a), (b) are cross-sectional views of an air-fuel sensor according to an prior art in the cases of detection in the lean region and the detection in the rich region, respectively; Fig. 4 is a cross-sectional view of the air-fuel sensor of Fig. 3; Fig. 5 is a characteristic diagram of a voltage and current of an air-fuel sensor; and Fig. 6 is a characteristic diagram of an air-fuel ratio and limit current.

1: Substrate, 2: Inside electrode, 3: Solid electrolysis layer, 4: Outside electrode, 5: Diffusion layer

Applicant of the utility model: Nippon Denshi Kiki Kabushiki Kaisha

Agent: Fujio SASAJIMA, Patent Attorney